



# CASE STUDY

## Wind Power takes flight in Denmark *Denmark's renewable energy policies*

### Key points

- ***From the initial start-up, to diffusion and up-scaling, the effective Danish policy mix implemented over the last two decades illustrates the importance of a timely and appropriate policy intervention in promoting renewable energy industries.***
- ***Community support is also important for technology dissemination.***

### There was a strong wind...

Although rich in natural resources,<sup>1</sup> Denmark was heavily reliant on imported fossil fuel until the 1970s. After the oil crisis in the mid-1970s, the Government decided to focus on wind power and combined heat and power. In 1986, the nuclear disaster in Chernobyl made the option of nuclear power generation politically unfeasible.<sup>2</sup>

### What was done?

To satisfy the strong energy demand, the Danish Government subsidized research and development on biomass, combined heat and power and photovoltaic and wind turbines and supported the associated emerging technologies through a package of policies. Denmark was one of the first countries to invest in wind turbines as part of a national policy, which eventually enabled it to become a global leader in wind power technology.

### ***Packaging and sequencing policies promoting wind power***

- 1) **Financial and technical support from the Government at the initial stage.** In 1978, the Government established a test station for wind turbines at the Riso National Laboratory. The Government then granted investment support for building and exporting wind turbines, initially at 40 per cent of the investment cost; but it was gradually reduced until 1989, when the support scheme was cancelled. Even with the financial support, only a few wind turbines were built in this period (figure 1).
- 2) **Setting targets.** In 1981, the Government launched its first energy plan, which included a goal of 1,000 MW of wind power by the year 2000. In *Energy 21*, the Danish Government's Action Plan for Energy<sup>3</sup> (published in 1999), the goal was to install 5,500 MW of electricity supply from wind turbines by 2030.
- 3) **Wind power increases only after the introduction of a feed-in tariff.** Wind turbine installation increased from 1984 to 2001, when the Government's support changed to a feed-in tariff,<sup>4</sup> with ensured grid connection. The Government mandated the utility sector to purchase wind energy at a preferential price and guaranteed wind power generators a fixed price of 70–85 per cent of the local retail price of electricity, excluding taxes. Although the energy tax had been introduced in 1981, in 1992 a carbon tax was added.<sup>5</sup> This made renewable energy more economically viable compared with fossil fuel.

<sup>1</sup> The degree of self-sufficiency rose from 5 per cent in 1980 to 145 per cent in 2002. Denmark is the third-largest oil producer (started producing net surplus of oil since 1993) in Western Europe and is dependent on domestic oil and natural gas for its primary energy supply.

<sup>2</sup> There are still no nuclear power plants in Denmark.

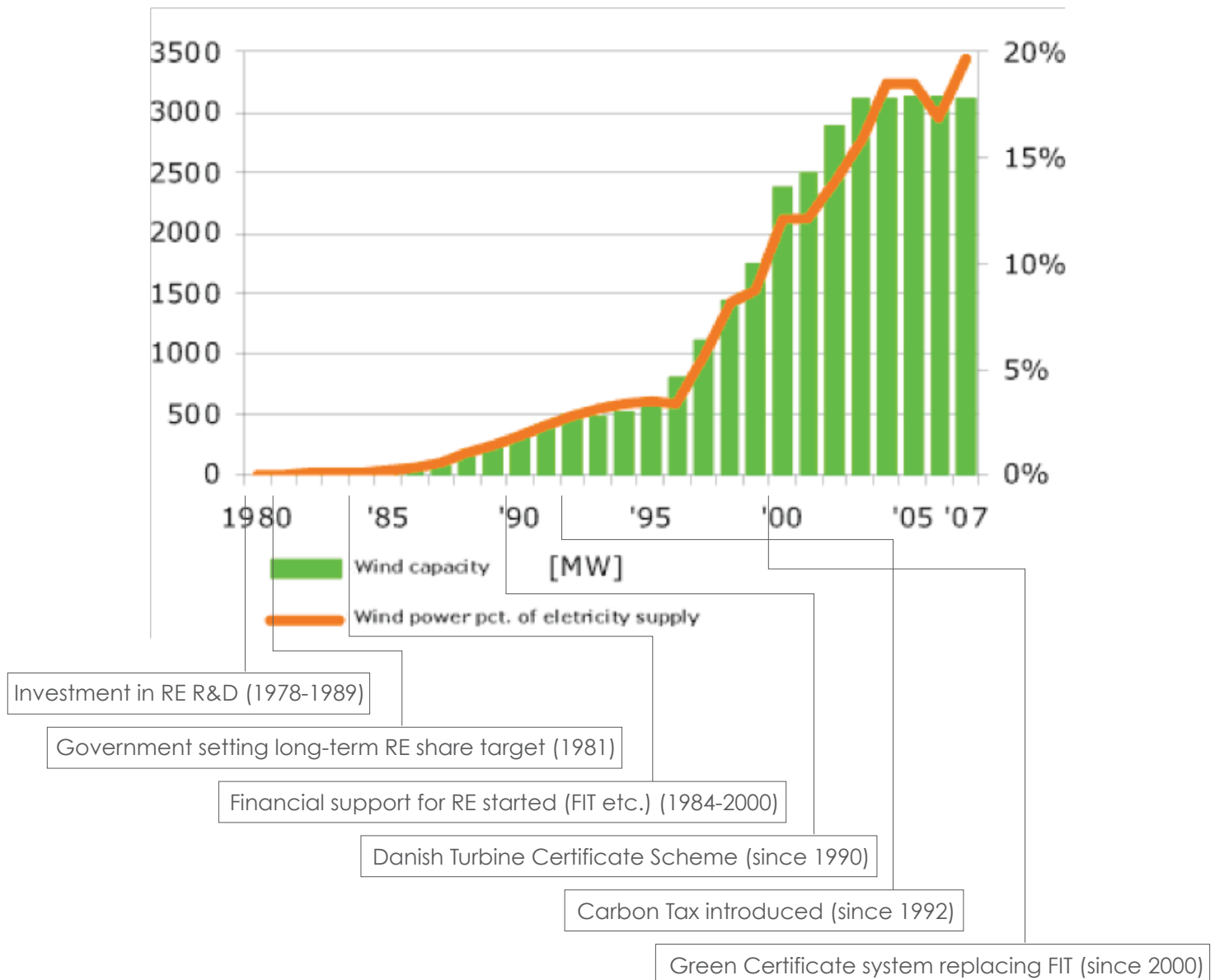
<sup>3</sup> Svend Auken, *Energy 21: the Danish Government's Action Plan for Energy* (1996). Available from [http://193.88.185.141/Graphics/publikationer/energipolitik\\_uk/e21uk/index.htm](http://193.88.185.141/Graphics/publikationer/energipolitik_uk/e21uk/index.htm) (accessed 22 January 2012).

<sup>4</sup> Danish Energy Authority, *Cost of the Public Service Obligation for Environmentally Benign Production of Electricity* (Copenhagen, 2009).

<sup>5</sup> Stefan Speck and Jirina Jilkova, *Design of Environmental Tax Reforms in Europe* (2009).

- 4) **Technology standards ensure quality.** Since 1990, Denmark's design, manufacture and installation of wind turbines, onshore as well as offshore, have been subject to the Danish Wind Turbine Certification Scheme, established by the Danish Energy Agency to ensure that safety, energy and quality-related requirements are followed.
- 5) **Green certificates supersede the feed-in tariff.** In 2000, the Government replaced the feed-in tariff with a system of green certificates<sup>6</sup> to encourage expansion of the renewable energy sector. The certificates are issued to producers of renewable electricity who can then trade them at a premium with anyone who wants to purchase renewable energy or who has an obligation to do so.

**Figure 1: Danish wind capacity development and renewable wind energy policy introduction**



NOTE: The graph has been modified by the author by marking the date and name of policy interventions.

Source: Danish Energy Agency, *Energy Statistics 2010* (Copenhagen, 2011). Available from [www.ens.dk/en-US/Info/FactsAndFigures/Energy\\_statistics\\_and\\_indicators/Annual%20Statistics/Documents/Energy%20Statistics%202010.pdf](http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Documents/Energy%20Statistics%202010.pdf) (accessed 30 January 2011).

<sup>6</sup> Ole Odgaard, *The Green Electricity Market in Denmark: Quotas, Certificates and International Trade* (Copenhagen, 2000). Available from [http://unfccc.int/files/meetings/workshops/other\\_meetings/application/pdf/dnkoo.pdf](http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/dnkoo.pdf) (accessed 21 January 2012).

## Community profiting critical

Community support for wind energy has been remarkable. Local cooperatives have installed more than 80 per cent of the wind turbines in Denmark. With a high fixed price for electricity generated from wind power, many communities regarded wind turbines as profitable investments. Some sought creative partnering, such as the Middelgrunden Wind Turbine Cooperative, an offshore wind turbine jointly owned by a local cooperative, the local utility (Copenhagen Energy<sup>7</sup>) and the Danish Wind Turbine Owners' Association.<sup>8</sup>

## Results

Denmark has been self-sufficient in energy since 1997.<sup>9</sup> Though rich in natural resources, it was one of the first countries to invest in wind turbines as a national policy in the 1970s. The field of wind power technology developed very quickly, starting in the 1980s, and accelerated over the next 10–15 years. In 2008, wind power supplied almost 20 per cent of the Danish electricity consumption, compared with an average of 2.4 per cent in Europe.<sup>10</sup> As of May 2010, 5,052 wind turbines had been installed that generated a wind power capacity of 3,752 MW,<sup>11</sup> with offshore wind power accounting for 720 MW.

Today, the wind power industry is a significant driver of Denmark's economic growth and competitiveness, enjoying a global market share of 40 per cent.<sup>12</sup> As of 2010, the exports of the wind energy industry accounted for 8.5 per cent of the total Danish exports, up from 7.2 per cent in 2008.<sup>13</sup> The success of the Danish wind power industry can be attributed to systematic and effective policy interventions over the past three decades in support of wind and other renewable energy-related industries.

## Lessons learned

**Governments need to be a driving force to move producer and consumer interests to green technology.** The successful take off of the Danish wind power industry since the mid-1980s was the result of the Government's consistent support of and investment in wind power technology since the 1970s. The ensuing sequencing of policies bridged the time gap between paying the initial investment costs for and reaping the benefits of the green industries. It is essential for governments to help jump start a new green industry if they want it to take the lead in a specific field.

**Ad hoc investments will not build up a green industry; governments need to provide long-term policies to assure investors.** Green technologies take time to finesse. Experiences show that ad hoc investments, focusing on short-time profits without any a long-term vision and consistent policy framework, may even postpone the developing momentum of green technologies.

**Policies need to be customized to the type of technology and energy.** Although wind power featured the most successful technology development, the Danish Government also supported other technologies in the 1970s and crafted specific policy support for each of them. Technology-specific policy measures are necessary due to the different factors involved in their innovation and dissemination processes. As the technology develops, policies also need to be updated accordingly to remain in line with the level of innovation. For example, the

<sup>7</sup> For more information see Middelgrunden website. Available from [www.middelgrunden.dk/middelgrunden/?q=en](http://www.middelgrunden.dk/middelgrunden/?q=en) (accessed 05 March 2012).

<sup>8</sup> For more information see Danish Wind Turbine Owners' Association website. Available from [www.dkvind.dk/eng/index.htm](http://www.dkvind.dk/eng/index.htm) (accessed 05 March 2012).

<sup>9</sup> Danish Energy Authority in the Danish Ministry of Economic and Business Affairs, *Energy in Denmark* (Copenhagen, 2003).

<sup>10</sup> Danish Wind Industry Association. Available from [www.vindselskab.dk/composite-1457.htm](http://www.vindselskab.dk/composite-1457.htm) (accessed 24 May 2011).

<sup>11</sup> Global Wind Energy Council, *Global Wind Report: Annual Market Update 2010* (Brussels, 2011). Available from [www.gwec.net/fileadmin/documents/Publications/Global\\_Wind\\_2007\\_report/GWEC%20Global%20Wind%20Report%202010%20low%20res.pdf](http://www.gwec.net/fileadmin/documents/Publications/Global_Wind_2007_report/GWEC%20Global%20Wind%20Report%202010%20low%20res.pdf) (accessed 20 January 2012).

<sup>12</sup> Danish Wind Industry Association. Available from [www.vindselskab.dk/composite-1457.htm](http://www.vindselskab.dk/composite-1457.htm) (accessed 24 May 2011).

<sup>13</sup> *Danish Wind Industry Association News*, "New all-time record in exports", 4 April 2004. Available from [www.windpower.org/en/news/news.html#719](http://www.windpower.org/en/news/news.html#719) (accessed 21 February 2012).

solutions to a specific problem related to the circulation of new technology (acquiring financial resources, distance to market, strength of the network grid and international playing field) differ with the type of technology addressed.

## Success factors

**Sequencing and packaging of public R&D support, long-term plans and financial scheme.** The Danish Government's intervention was essential for the wind power industry's success, specifically:

- Research and development funding at the initial stage
- Long-term commitment to specific and ambitious renewable energy targets
- Financial support (feed-in tariff, etc.) to ensure that targets are reached
- Access to transmission infrastructure at the initial stage and strategic expansion of infrastructure
- Streamlined planning and procedures for obtaining permits.

## Consideration for replicating

To promote the installation of offshore wind power, many countries are using the feed-in tariff example that Denmark set, such as Germany, Japan, Netherlands and the United Kingdom. Whether the feed-in tariff alone is sufficient to support technology development and to stimulate the market or whether it needs to be combined with other complementary policies, as in the case of Denmark, is a consideration for policymakers looking at the specific context and conditions in their country.

### Box : The success of Vestas Wind Systems A/S

More than 200 Danish companies are associated with the wind power generation in Denmark, featuring a unique component supply chain (including metal processors, sensor and controlling systems, platforms and foundations). Due to the continuous entry of new businesses into the wind energy market, the Danish market share has been decreasing. Some companies, though, have managed to remain soaring, such as Vesta Wind Systems A/S. It is one of the world's leading manufacturers of large-scale and offshore wind turbines, with a global share of 16 per cent; it installed and delivered 5,842 MW in 2010.<sup>14</sup> Vestas has installed more than 43,000 wind turbines in 66 countries on six continents. It is currently developing 6 MW class wind turbines, which will be more economical for generating electricity. Vestas pioneered the development and installation of the first-ever offshore wind turbines in Sweden in 1990. The company employed a total of 21,600 people in 2009, more than 500 of them top engineers posted around the world.<sup>15</sup>

Source: Vestas, *Full Year 2010 and Guidance for 2011: Operating in a Market in Recovery* (Copenhagen, 2010). Available from [www.vestas.com/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fEN%2fInvestor%2fFinancial\\_presentations%2f2010%2f2010\\_AR\\_PRES\\_UK.pdf](http://www.vestas.com/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fEN%2fInvestor%2fFinancial_presentations%2f2010%2f2010_AR_PRES_UK.pdf) (accessed 18 January 2012).

## Further reading

See the website of the Danish Energy Agency. Available from [www.ens.dk](http://www.ens.dk).

See the website of Vestas Wind Systems A/S. Available from [www.vestas.com](http://www.vestas.com).

<sup>14</sup> Vestas, *Full Year 2010 and Guidance for 2011: Operating in a Market in Recovery* (2010). Available from [www.vestas.com/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fEN%2fInvestor%2fFinancial\\_presentations%2f2010%2f2010\\_AR\\_PRES\\_UK.pdf](http://www.vestas.com/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fEN%2fInvestor%2fFinancial_presentations%2f2010%2f2010_AR_PRES_UK.pdf) (accessed 18 January 2012).

<sup>15</sup> *ibid.*